# WIRELESS PURCHASE AND ON-LINE INVENTORY APPARATUS AND METHOD FOR VENDING MACHINES

## FIELD OF THE INVENTION

The present invention relates generally to an apparatus of and a method for wireless purchase of merchandise. In particular, the present invention relates to an apparatus of and a method for controlling wireless purchase from a vending machine by using a cellular phone. Further, the present invention relates to on-line inventory management, inventory data acquisition and monitoring, and vending machine control.

## DESCRIPTION OF THE PRIOR ART

A "vending machine" generally refers to a coin-operated machine that automatically dispenses a merchandise upon the receipt of a payment equal to or greater than a predetermined sale price. Even though many vending machines are now designed to accept paper bills, electronic stored value cards, or credit cards as alternate payment methods, coin-operated vending machines remain the largest in number.

A major feature of vending machines is that the vending operation is fully automatic with no need of human supervision. Accordingly, various vending machines have been used at locations where it is not cost effective to have a normal manned merchandise outlet or where 24-hour sale service is needed. The merchandise dispensed from vending machines typically include drinks, food, tobacco, stamps, newspaper, parking tickets, phone cards, and etc. The storage compartments in a vending machine may contain different merchandise inventory at different predetermined sale prices.

Usually, vending machines are grouped into routes; one or more of these routes are managed by an operator. The operator sends service personnel to regularly refill the inventory, change merchandise, remove collected coins or bills, refill money changer, and perform other maintenance services. In most cases, refill and maintenance service is carried out based on historical figures, which is the service frequency depends on past history of a particular vending machine at a particular location. As sale patterns may vary among vending machines at different sites and at different times, the historical data may cause undesirable inefficiencies in the management of the vending machines. Accordingly, an automated method or apparatus is desired to collect on-line inventory data. Furthermore, the large number of cellular mobile phone users also creates the opportunity of payment by mobile phones. Therefore, it is desirable to provide a method or an apparatus allowing online payment for purchase made from vending machines.

A number of U.S. patents have addressed the aspect of vending machine inventory management. U.S. Patent No.6,056,194 issued to Brock Kolls on May 2, 2000 and entitled "System and Method for Networking and Controlling Vending Machines" discloses a vending machine control system and method for controlling vending of items from one or more vending machines operated by credit cards, debit cards, pre-pay cards, bills, or coins via a network.

U.S. Patent No.5,930,771 issued to D. S. Stapp on July 27, 1999 and entitled "Inventory Control and Remote Monitoring Apparatus and Method for Coin-operable Vending Machines" uses bar code scanner to log inventory into a memory with each vending machine and uses cellular telephone interface and modem to transmit the vending information back to a central computer. The Stapp patent focuses on the bar code scanner embedded at racks and claims one cellular number used for a plurality of vending machines.

U.S. Patent No.5,794,144 issued to E. I. Comer et al. on August 11, 1998 and entitled "Methods and Apparatus for Communicating Data via a Cellular Mobile Radiotelephone System" describes a data collection system based on cellular network control channel, together with a paging message system for acknowledgment. The Comer patent focuses exclusively on the use of the control channel in the cellular network and the paging approach.

U.S. Patent No.5,963,452 issued to T. Etoh et al. on October 5, 1999 and entitled "System for Managing Sales of Goods for Vending Machines" discusses the use of frequency modulated sub-carrier broadcasting facility for communication between a goods control center and the terminal computers. The Etoh patent focuses on the control of the vending machines via control commands from the control center, and extracting market information of the vending machines.

U.S. Patent No.4,412,292 issued to J. K. Sedam et al. on October 25, 1983 and entitled "System for the Remote Monitoring of Vending Machines" describes a system using telephone line to communicate information obtained by a microprocessor in a vending machine. The Sedam patent focuses mainly on a plurality of sensors in a vending machine to establish alert conditions and to control inventory, route planning of the machines.

Although the above U.S. patents disclose systems using cellular telephone network to communicate for on-line inventory control purpose, none of these patents discusses the use of the short message service (SMS) protocol. Furthermore, apart from inventory control, none of the patents discloses using a cellular mobile phone to purchase merchandise and to make the payment, let along a fully integrated solution to the purchase and on-line inventory problem.

## SUMMARY OF THE INVENTION

The present invention provides an alternate merchandise purchasing method that can co-exist with all the other purchasing schemes, including coins, bills, stored value cards, or credit cards available to vending machines.

The present invention also integrates the purchasing function with the on-line inventory function so that a single apparatus can handle the purchase of merchandise, monitor the inventory, and communicate with a central computer.

The present invention relates to an apparatus and a method for wireless purchase of merchandise from a vending machine by using a cellular mobile phone. The present invention permits a cellular mobile phone user to dial a sequence of code on the phone to invoke the vending machine to dispense merchandise, where payment is charged to the mobile phone account. The present invention also relates to an apparatus and a method for on-line inventory management. With on-line inventory management, the present invention provides high efficient operation, reduced operation cost, and just-in-time service and merchandise delivery. The present invention further relates to an apparatus and a method that allow both on-line inventory management and wireless purchase of merchandise in a vending machine.

The apparatus and method of the present invention have at least the following features that are not found in any of the existing vending machines. (1) The present invention is generic enough to be integrated into either mechanical type or electronic type vending machines. (2) The present invention uses wireless modem that communicates with other mobile phones or a central computer via the commercial cellular mobile network. (3) The present invention uses the SMS protocol. The inventory data is further encoded with cyclic redundancy code for error checking. (4) The present invention employs the micro-controller technology and utilizes mixed-mode analog-digital circuit interfacing technologies for data acquisition, processing and storage. (5) The present invention provides a method of inventory data protection against data loss due to power failure, transient, or intentional power down. (6) The present invention is fully programmable and can be programmed to perform a multitude of tasks. (7) The present invention is based on a distributed architecture that each vending machine in the plurality of vending machines operates independently, without requiring authorization from a central computer. (8) The present invention is designed to co-exist with other payment devices. (9) The present invention deployed in large numbers, with low probability of communication congestion.

In the present invention, each vending machine is equipped with a control and communication unit (CCU). The CCU can comprise one or more of the following: a

micro-controller, a cellular mobile phone modem, a power management circuit, a battery, a display panel, a quantity counter interface, a refill/service switch interface, a door switch interface, a reset switch, a coin mech signal detection and simulation circuit, a merchandise dispensing interface circuit, a merchandise selection interface circuit, and a sold out interface circuit. The CCU can be connected to an AC power supply derived from the vending machine and further connected to the sold out circuit, the merchandise dispensing device, the coin mech, and the counter of the vending machine.

The micro-controller is capable of running a resident program in the read-only memory of the micro-controller to carry out various actions. Exemplary actions performed by the micro-controller are shown below without any particular order. (1) The micro-controller can serve interrupting signals from the sold out circuit, the dispensing circuit, the quantity counter, the refill/service switch, the door switch, and/or the reset switch. (2) The micro-controller can encode and pack the inventory data into a format and size suitable for SMS communication. (3) The micro-controller can detect the presence of the coin mech signal and arbitrate between the coin or card purchase and the cellular phone purchase. (4) The micro-controller can enable the coin mech simulation signals to initiate a vending transaction. (5) The micro-controller can record the quantity counter and refill/service switch signals and include that as part of the inventory data. (6) The micro-controller can display part of the cellular mobile phone number or other messages on the display panel. (7) The micro-controller can initiate and control the communication with a central computer via a wireless modem. (8) The micro-controller can control and receive data from a central computer and then take appropriate actions. (9) The micro-controller can control and receive data from a purchaser's phone, verify the coded sequence, and initiate the purchase. (10) The micro-controller can perform a software reset when the reset switch is pressed. (11) The micro-controller can record the date and time when the door switch is activated. Other standard functions of the micro-controller may include management of the on-board memory banks and referencing the real-time clock.

The functions of the sold out interface circuit, the merchandise dispensing interface circuit, the quantity counter, and the refill/service switch can be broadly viewed as inventory data collection. These components are capable of collecting one or more types of the following information: sold out data, the storage compartment from which the merchandise is dispensed, the total number of merchandise sold since the day of first installation, and the type of service carried out.

The functions of the coin mech signal detection and simulation circuit are to detect and simulate the coin mech signals under certain situations. When an appropriate payment of coins has been inserted through and accepted by the coin mech, the coin mech

signals are active. The coin mech signals then drive a converter in the vending machine to allow a purchaser to select merchandise on the display panel of the vending machine via a number of buttons. On the other hand, when a wireless purchase is carried out, equivalent signals are simulated to activate the display panel and selection buttons for merchandise selection. To prevent signal contention, any coin mech signals, if active, must be detected. Once detected, the coin mech signals can interrupt the micro-controller, which can then serve the interrupt by disabling the wireless purchase in the earliest instance. It will be appreciated that other payment devices may be similarly interfaced with the vending machine. The payment priority can be determined as desired in advance for a smooth vending operation.

The display panel is capable of displaying partial phone number of the purchaser whose purchase request the vending machine is serving at the time. Therefore, the display function can notify the purchasers of the ongoing transaction. Because the display panel shows only part of the phone number, there is no concern of violating privacy. The display panel can also be used to display other messages during the system start-up, system testing, and cash transaction.

The power management circuit is capable of providing the required power supply to the micro-controller and its peripheral devices when an AC power supply is applied. Additionally or alternatively, the power management circuit is capable of providing a backup battery supply when the AC power supply is removed or unstable. When the latter occurs, the power management circuit detects a voltage drop and starts counting in a timing loop. During the voltage drop period, the backup battery is used as power supply. However, the battery is not intended for carrying out normal operations. If the voltage drop lasts after a predetermined period of time has elapsed, the power management circuit signals the micro-controller that a power down condition has occurred. Upon receiving this confirmation, the micro-controller immediately forwards all the vending transaction information obtained since the last reporting time to a central computer. The micro-controller enters into a sleeping mode to conserve battery power after sending all the information and receiving an acknowledgment from the central computer. If the voltage level returns to the normal level within the predetermined period of time, the power management circuit switches back to the AC power supply. Normal operations resume.

The wireless modem is capable of establishing a communication link with the purchaser's mobile phone and/or with a central computer. As a cellular mobile phone modem, it can receive and transmit SMS over the existing commercial mobile network. When a purchaser dials the code from a cellular phone, the phone communicates with the wireless modem. The wireless modem in turn sends an interrupt to the micro-controller.

The micro-controller serves the interrupt by turning on the display buttons on the panel of the vending machine to allow the purchaser select merchandise via the buttons. As to the communication between the vending machine and a central computer, the communication can be both directions. On one hand, the micro-controller is capable of automatically packing the vending transaction information and transmitting them to the central computer, when a predetermined period of time has elapsed, or an alert level becomes active, or the contents of the transaction information has reached a certain size in the memory storage. On the other hand, the central computer is capable of requesting for vending transaction information by sending a SMS to the vending machine where, after verifying the sender identity, the micro-controller automatically packs the vending transaction information since the last reporting time and transmits them to the central computer.

When a plurality of vending machines are employed in a wireless purchase and on-line inventory management apparatus, each vending machine can be identified uniquely by a central computer through an identification phone number. Such identification phone number differs from the short code used for wireless purchase and is unknown to the purchasers. The identification phone number is used by all the backend operations to identify the machine or the inventory data associated with the machine. The central computer can consist of one or more of the following: a Windows NT computer, an X.25 data modem card, an X.25 data line connecting the computer to the mobile network provider, a gateway service program, a control program, and a database. The use of the X.25 data link instead of a wireless modem is to ensure high communication integrity. The gateway service program can control the data line operation and buffering. The control program is capable of interfacing with the gateway service program, supporting visualization, controlling data flow, manipulating data, keeping log of the incoming and outgoing data and events, and writing data into a database. The database is capable of collating the data for data analysis, route planning, inventory control, and other management purposes.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more apparent from the following description in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram depicting a vending machine of a mechanical type;

Fig. 2 is a block diagram depicting a vending machine of an electronic type;

Fig. 3 is a block diagram of the control and communication unit (CCU) of the present invention;

Fig. 4 is a schematic diagram of the micro-controller circuit of the present invention;

Fig. 5 is a schematic diagram of the power management circuit of the present invention;

Fig. 6 is a schematic diagram of the merchandise dispensing interface circuit of the present invention;

Fig. 7 is a schematic diagram of the sold out interface circuit of the present invention;

Fig. 8 is a schematic diagram of the coin detection and simulation circuit of the present invention;

Fig. 9 depicts the interface between the CCU and the vending machine of a mechanical type of the present invention;

Fig. 10 depicts the interface between the CCU and the vending machine of a electronic type of the present invention;

Fig. 11 depicts the concept of wireless purchase through a cellular mobile phone of the present invention;

Fig. 12 depicts the command and data flow of wireless purchase of the present invention;

Fig. 13 depicts the on-line inventory management configuration of the present invention; and

Fig. 14 depicts the command and data flow of on-line inventory of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Exemplary wireless purchase and on-line inventory apparatus and method embodying the principles of the present invention are shown throughout the drawings. Currently, two types of vending machines are commonly used. They are the mechanical type vending machine **10** and the electronic type vending machine **30** as illustrated in Fig. 1 and Fig. 2, respectively. The difference between the two types of vending machines **10** and **30** is that the electronic type vending machine **30** has an additional electronic unit **34** that can log and store inventory data locally in the vending machine. By using a keypad attached to the electronic unit **34**, the user may control the dispensing mechanism, select storage compartments, and/or run a series of tests to verify the operation of the vending machine **30**. A printer can also be attached to the electronic unit **34** for printing inventory data. Both types of vending machines **10** and **30** can have other electrical circuits for lightings, condensers, motor, compressor, and thermostats for the storage of merchandises,

depending on the type of merchandises on sale. The following description focuses on the vending operation of the vending machines **10** and **30**.

Fig. 1 is a block diagram showing an exemplary mechanical type vending machine **10**. The vending machine **10** may consist of a vending controller **11** for controlling the vending operation, a coin mech **13** for receiving payment, a display controller **15** for driving a display panel and selection buttons **12**, and a number of storage compartments **16** for keeping merchandises **20**. It is understood that the vending machine **10** can be varied as desired. For a mechanical type vending machines **10**, purchase is made through the coin mech **13**. The coin mech **13** can be configured to accept **19** payment, such as tokens, coins or paper money. After receiving a payment, the coin mech **13** can output a purchase signal **21** to the display controller **15**. The coin mech output signal **21** can be in AC and represent different price levels and other control functions that can be adjusted in the coin mech **13** itself.

Upon receipt of the purchase signal **21**, the display controller **15** then drives the display panel and the selection buttons **12** allowing the user to select merchandises **20**. The display panel can display the types of merchandises **20** that can be purchased from the vending machine **10**. The display panel can be either an LCD or an LED. Additionally or alternatively, the display panel can include one or more selection buttons for the user to select the merchandises **20**. The selection buttons can be associated with the storage compartments **16** in various manners. In an exemplary embodiment, one selection button corresponds to one or more storage compartment **16**.

Each storage compartment **16** can be constructed to contain one or more merchandises **20** of the same type or of different types. The storage compartment may have a dispensing member **17**, such as a dispensing solenoid, adapted to dispense one piece of the merchandises **20**. In an exemplary embodiment, the dispensing solenoid **17** can mechanically move **22** a device holding the merchandise **20** and, as a result, dispenses **27** a piece of merchandise **20** from that storage compartment **16**. When a button on the display panel is pressed, a selection signal **24** is sent to the vending controller **11**. The vending controller **11** can then activate **25** the dispensing member **17** corresponding to the selected storage compartment **16**. After the merchandise **20** is dispensed, the dispensing member **17** or the storage compartment **16** sends a return signal **21** to the coin mech **13** and the display controller **15** to confirm the completion of the transaction.

In an alternative embodiment, a sold out sensor **14** can be provided for detecting the absence of any merchandise **20** in any storage compartment **16**. In an exemplary embodiment, each storage compartment **16** is connected with a sold out sensor **14**. If an absence condition is detected in a storage compartment **16**, the sold out sensor **14**

can return **23-26-24** an active sold out signal to the display controller **15**. The display controller **15** can then disables the corresponding selection button(s) on the display panel.

Fig. 2 is a block diagram showing an exemplary electronic type vending machine **30** that can include similar vending functions to those of the mechanical type vending machine **10** as described above. In addition, the electronic type vending machine **30** can have an electronic unit **34** that interfaces **43, 46** with the coin mech **13** and the display and vending controllers **31, 33**. The electronic unit **34** is capable of recording vending transaction information, such as information about what storage compartment **16** has dispensed and/or what storage compartment **16** has sold out. The vending transaction information can be stored in various formats, such as a proprietary format for down-loading onto a printer on-site. Additionally or alternatively, the electronic unit **34** can be adapted to control the vending operation during the service. In an exemplary embodiment, the electronic unit **34** can interface **47** with a keypad to control the dispensing directly or run a series of tests on the display and vending controllers **31, 33**. It is understood that the vending machine **30** can be varied as desired.

Fig. 3 is a block diagram depicting a preferred embodiment of a control and communication unit (CCU) **100** formed according to the principles of the present invention. The CCU **100** may comprise a micro-controller circuit (MC) **150** with a power management circuit **170**, a coin simulation interface (CSI) circuit **230** for communicating with a vending machine, and a wireless modem interface circuit **112** for communicating with a network.

As shown in Fig. 3, the CCU **100** can also have a parallel interface circuit including one or more of the following circuits: a sold out interface (SOI) **200**, a merchandise dispensing interface (MDI) **210**, a coin detection interface (CDI) **220**, and a card reader interfacing circuit (CIC) **105**. The interface circuits for the SOI **200**, the MDI **210**, the CDI circuit **220**, and the CSI circuit **230** are capable of performing level shifting and isolation between the signal levels **118, 119,** and **122** used by the vending machine and the standard TTL signal level used by the micro-controller. The interface between the CIC **105** and a card reader (not shown) is carried out via a serial link **120**. In another preferred embodiment, the CDI circuit **220** and the CSI circuit **230** can be combined to form a coin detection and simulation interface (CDS) circuit. The CDS can form a portion of the above parallel interface circuit.

In a preferred embodiment, the CCU **100** can further have one or more of the following circuits: a display panel interface circuit **101**, a quantity counter interface circuit **102**, a refill/service switch interface **103**, and a door switch interface **104**. The display panel interface circuit **101** is capable of communicating a message pertaining a wireless purchase from the MC **150** to the display panel of the vending machine. For example,

messages, such as a portion of the phone number of the purchaser, can be shown on the display panel during the wireless purchase to indicate whose merchandise is being dispensed. The quantity counter interface circuit **102** is capable of communicating between the MC **150** and the quantity counter. The interface between the door switch and quantity counter is also in parallel **125, 126**. The interface with the display panel may differ from the rest because there may not be level shifting or isolation through a parallel data line **124**. It will be appreciated that various alternate embodiments of the CCU **100** are within the scope of the present invention.

The micro-controller circuit (MC) **150** is the computing core of the CCU **100**, where all input data **114, 115, 116, 117, 121, 125, 126,** and **130** are stored and processed as described below. It will be appreciated that the MC **150** can also perform other output functions, such as (a) enabling the coin mech signal simulation via a parallel interface with level shifting **121**, (b) displaying information on the display panel through a parallel interface **124**, and (c) transmitting via the cellular mobile channel **113** all the transaction information to a control center via a serial data link **114**. In a preferred embodiment, the MC **150** can include a DC power supply **127**, which can be derived from the power management circuit **170**. The power management circuit **170** can be generated either from an AC supply **110** or a battery **173** determined by the AC supply **110** as described in greater detail below.

Fig. 4 depicts a preferred embodiment of the MC **150** formed according to the principles of the present invention. The MC **150** can comprise a central processing unit **151** and one or more of the following devices: a memory bank **152**, a plurality of programmable peripheral interface devices (PPI) **155**, an address decoder **156**, a buffer **157**, a clock such as a real-time clock **158**, a transceiver such as an RS232 serial transceiver **159**, and a watchdog circuit **165**. The memory bank **152** may include a read only memory **153**, such as an electrically programmable read only memory (EPROM), and a random access memory (RAM) **154**.

The central processing unit (CPU) **151** in the MC **150** can communicate and control the other devices through a data bus **161**, a control bus **162**, and an address bus **163**. In a preferred embodiment, the CPU **151** is capable of executing a program stored in the EPROM **153** that performs initialization of devices in the circuit. The CPU **151** can also process the data to and from the PPI **155** and communicate through an RS232 port **160** with a wireless modem and onto a central computer. Further, the CPU **151** can communicate with a card reader via the RS232 port **160**. The data processing tasks performed by the CPU **151** may include, but not be limited to, servicing interrupts from the various interface circuits, the quantity counter, and the refill/service switch, displaying appropriate messages

and information on the display panel, and detecting AC power down condition from the power management circuit **170**. It will be appreciated that various alternate embodiments of the CPU **151** are within the scope of the present invention.

The memory bank **152** in the MC **150** is capable of storing various program/information of the CCU **100**. In a preferred embodiment of the present invention, the system control program may be stored in the EPROM **153** while the vending transaction information may be stored in the RAM **154**. The vending transaction information can be accumulated until a predetermined time period is reached, or a request is received from the central computer, or a predetermined maximum number of vending transactions is reached. Then, the vending transaction information is packed into an SMS format and sent to the central computer. It will be appreciated that various alternate embodiments of the memory bank **152** are within the scope of the present invention.

The PPI **155** in the MC **150** is adapted to establish communication and data flow **164** between the CPU **151** and one or more of the following: the merchandise dispensing interface circuit **210**, the sold out interface circuit **200**, the coin detection and simulation circuit **220, 230**, refill/service switch **103**, door switch **104**, and quantity counter **102**. In a preferred embodiment, the communication and data flow **164** can be one or more of the following: merchandise dispensing signals, sold out signals, coin detection and simulation signals, refill/service confirmation, door switch signals, and quantity counter signals. The MC **150** can thus directly control the display panel and send messages to the display panel at different execution stages of the program.

The address decoder **156** in the MC **150** can be used to decode addresses for the PPI **155**, the RAM **154**, the EPROM **153**, the display panel, and/or the clock **158**. An additional buffer **157** can be used for storing data from the PPI **155** after an interrupt, which is forwarded to the CPU **151** in due course.

In a preferred embodiment, the clock **158** is a real-time clock for time and date stamping the transaction information. The clock **158** can be calibrated with the time obtained from the cellular mobile network when the system first starts up. Additionally or alternatively, the clock **158** can be regularly calibrated from the same time source. A watchdog circuit **165** can also be included in the micro-controller circuit to provide software reset **166** to the CPU **151** if and when the firmware execution is irregular. It will be appreciated that various alternate embodiments of the MC **150** and its various components are within the scope of the present invention.

Fig. 5 depicts a preferred embodiment of the power management (PM) circuit **170**. The PM **170** may comprise one or more of the following: a full-wave rectifier **172**, a battery **173**, a voltage limit charger **174**, a switching power supply **175** for the micro-

controller **150**, an AC main detector **178**, a low voltage detector **177**, a power shut down circuit **176**, and a micro-controller shut down detector **179**. It will be appreciated that various alternate embodiments of the PM **100** or its components are within the scope of the present invention.

Driven by an AC supply **171**, the full-wave rectifier **172** may produce a smooth DC voltage **187** that can be used to charge the battery **173**. In a preferred embodiment, the voltage-limit charger **174** charges the battery **173** with variable current values. The output **188** of the charger **174** is used to drive a switching power supply circuit **175**. The switching power supply circuit **175** can provide necessary output voltage levels **185**, **184,** and **183** to drive the wireless modem **112**, the MC **150**, and other circuits.

The main AC detector **178** can detect any drop in the AC supply **171**. The AC supply drop can result from unstable power caused by a transient, power failure, or the termination of power supply. Upon detecting this condition, the main AC detector **178** returns an active signal **181** to the MC **150** via the power shut down circuit **176**. As the switching supply **175** is connected to the battery charger **174** and the battery **173**, the power supply to the micro-controller **150** can then be taken over by the battery **173**.

When the MC **150** receives an active signal **182** from the power shut down circuit **176**, the MC **150** completes all the current transactions before forwarding all the vending transaction information to the central computer. If the duration of the active signal **182** is more than a predetermined period of time, the MC **150** enters into a shut down state and disables the wireless purchase and on-line inventory functions. Otherwise, the MC **150** will restores its full set of functions. When the MC **150** enters into a shut down state, the MC **150** sends a shut down signal **191** to the MC shut down detector **179**. The MC shut down detector **179** then outputs a signal **180** to the low voltage detector **177** and turns off the supply to the MC **150** and the wireless modem **112**. The low voltage detector **177** can also detect the output voltage level of the battery **173**. If the output voltage level is low, an active signal **186** is returned to the MC **150** via the power shut down circuit **176**. Supply can be restored when the main AC detector **178** detects the main AC power supply again.

Fig. 6 depicts a preferred embodiment of the merchandise dispensing interface (MDI) circuit **210** formed according to the principles of the present invention. The MDI **210** may comprise the interface between the dispensing signals **214** from the storage compartments **16** and the MC **150**. For each dispensing signal **214**, an optical coupler **211** is used for isolation and a level converter **212** is used to translate the AC signal into a TTL compatible signal level **217**. For a typical twenty compartments vending machine, there are twenty identical sections of the interface. The translated TTL dispensing signals **217** can be multiplexed **213** into a binary word **215** with word length sufficient to represent the number

of compartments **16**. In an exemplary embodiment where there are twenty compartments **16**, five bits can be used to uniquely represent a compartment **16** from which a merchandise **20** is dispensed. These binary outputs can be also hardwired-OR together to form an interrupt signal **216** to interrupt the MC **150** when an active signal is detected at any one of the input lines. Upon receiving this interrupt signal, the MC **150** latches the output binary word **215** and appends the compartment number to the transaction record. It will be appreciated that various alternate embodiments of the MDI **210** are within the scope of the present invention.

Fig. 7 depicts a preferred embodiment of the sold out circuit (SOI) **200** formed according to the principles of the present invention. The SOI **200** may comprise the interface between the sold out signals **203** from the storage compartments **16** and the MC **150**. For each sold out signal input, an optical coupler **201** is used for isolation and a level converter **202** is used to translate the AC signal **203** into a TTL compatible signal level **204**. In the above exemplary embodiment of twenty compartments vending machine, there can be twenty identical sections of the interface. As there may be more than one compartments **16** having an active sold out signal **203** simultaneously, the TTL version of the sold out signals **204** are output to the MC **150** as they are without any multiplexing. As these sold out signals **204** may be active until the sold out compartments **16** are refilled, therefore, the latching of the sold out signals **204** into the MC **150** is not done by interrupt. It will be appreciated that various alternate embodiments of the SOI **200** are within the scope of the present invention.

Fig. 8 depicts a preferred embodiment of the coin detection and simulation interface (CDS) circuit formed according to the principles of the present invention. The CDS may comprise two sub-modules **220, 230**. The first sub-module is a coin detection module **220** for detecting any price signal **223** from the coin mech of the vending machine (Fig. 8(a)). For the price signal detection module **220**, similar optical coupler **221** and level converter **222** combination is used. If one or more price signals **223** are active, then the coin inserted condition is true. Consequently, the coin mech active signal **225** is pulled active. To accommodate this, the price lines are hardwired together at the input. When the output price signal **223** is active, the output price signal **223** interrupts the MC **150**. The MC **150** permits the cash operation to complete while the cellular mobile phone dial-in is disabled.

The second sub-module is a coin simulation module **230** for simulating price signals to be sent to the vending machine converter (Fig. 8(b)). The simulation module **230** can consist of a plurality of identical sections of switches **231** that derive their identical input **232** from the MC **150**. In an exemplary embodiment, four sections of switches **231**

are adopted. This input signal **232** from the MC **150** switches the connection between the coin mech price signals **233** to the vending machine controller **234**, and a signal of equivalent signal level **235** as the price signals (110 V for example) to the display controller. The purpose of the equivalent signal level is to simulate the price signals. In this case, the switching of all the sections is synchronous, allowing the purchaser to select any merchandise **20** in any of the compartments **16**. It will be appreciated that various alternate embodiments of the CDS or its sub-modules **220, 230** are within the scope of the present invention.

The interface of the CCU **100** with the existing vending machine will be described in connection with Figs. 9 and 10, where the vending machine is of a mechanical type **250** in Fig. 9 and of an electronic type **270, 300** in Fig. 10. In a preferred embodiment as shown in Fig. 9, the input signals to the CCU **100** may include one of more of the following: a group of dispensing signals **267** from the dispensing devices **255**, a group of sold out signals **266** from the sold out devices **256**, and/or a group of coin mech signals **259** from the coin mech **253**. The dispensing signals **267** can be used to identify the storage compartment **257** that has been activated to dispense a merchandise **268**. The sold out signals **266** can be used to identify what storage compartment is empty. The coin mech signals **259** can be used to identify what price line has been activated.

It will be appreciated that these input signals may be used for other purposes. In another preferred embodiment, the coin mech signals **259** can be used for vending arbitration. Accordingly, when one of the coin mech signals **259** is active, the wireless purchase function is suspended until the coin operation is completed. Similarly, when a wireless purchase is in progress, the coin mech **253** will be disabled.

The output signals from the CCU **100** to the vending machine **250** can include the simulated signals **258**. In a preferred embodiment, the simulated signals **258** are communicated to the display controller **251**. The purpose of this group of signals **258** is to simulate purchase signals of similar electrical characteristics as the coin mech signals **259** when a wireless purchase function is activated. In a preferred embodiment of the present invention, the simulated signals **258** are treated as if they were generated from the coin mech **253**. Accordingly, the subsequent interpretation of these simulated signals **258** by the display controller **251** can be identical to that of the coin mech signals **259**. It will be appreciated that various alternate embodiments of the interface between the CCU **100** and existing mechanical vending machines **250** are within the scope of the present invention.

Figs. 10(a) and 10(b) depict preferred embodiments of the interface between the CCU **100** and an electronic type vending machine **270, 300** of the present invention. In Fig. 10(a), the interface between the CCU **100** and the electronic type vending machine **270**

assumes no knowledge of the electronic unit **273** and works similarly as the interface with the mechanical type vending machine **250** as described above. In Fig. 10(b), the interface between the CCU **100** and the electronic type vending machine **300** is carried out through an electronic unit **305**, which requires the knowledge of the data protocol used in the electronic unit **305**.

In a preferred embodiment as shown in Fig. 10(b), there is no direct interface between the dispensing and sold out signals. Instead, an existing communication link **320** of the electronic unit **305** is used. This requires a serial connection between the electronic unit **305** and the CCU **100**. Based on this interconnection, the inventory information in the electronic unit **305** may be extracted and returned to the CCU **100** directly. To enable this to occur, the knowledge of the protocol used in communication with the electronic unit **305** and its data format is essential for this interfacing configuration. It will be appreciated that various alternate embodiments of the interface between the CCU **100** and existing electronic vending machines **270, 300** are within the scope of the present invention.

Fig. 11 depicts a preferred embodiment of wireless purchase **350** according to the principles of the present invention. According to this preferred embodiment, the wireless purchase **350** can contain the following simple steps: (1) purchaser dials up a number **354** displayed on the vending machine **351**; (2) vending machine **351** receives the call **355** directly; (3) vending machine **351** performs data verification and, if correct, activates the merchandise **20** to be selected; (4) purchaser selects merchandise **20** on the vending machine's display panel **356**; and (5) vending machine **351** dispenses **357** the merchandise. It will be appreciated that various alternate embodiments of the wireless purchase **350** are within the scope of the present invention.

In an exemplary embodiment, the purchaser may initiate the purchase by dialing an encoded short code displayed on the vending machine **351**, without having to go through the lengthy procedure of sending an SMS. This short code may be in the form of "*xy1234" **354**, in which "1234" is a unique identification number of the vending machine **351**. The short code is received by the cellular mobile network system **352**, where the short code is decoded and mapped to the cellular mobile number of the vending machine concerned. This enables an SMS request **355** to be sent to the vending machine **351**.

Upon receipt of the request communicated from the mobile network, the vending machine **351** performs data verification inside the CCU **358** to ensure that the SMS is for purchasing merchandise, rather than other type of SMS messages. If the SMS passes the verification stage, the CCU **358** activates the coin mech signal simulation circuit **230** and enables the purchaser to select merchandise by using the buttons on the display panel of the vending machine **351**. At the same time, information regarding the date, time, and the

purchaser's phone number can be temporarily stored in the RAM. In addition, a portion of the purchaser's phone number can be displayed on the CCU's display panel.

If a selection is made within a certain time, the transaction is considered complete. The storage compartment from which the merchandise is dispensed is recorded and appended to the current transaction information and marked as a valid vending transaction. Otherwise, the transaction is considered incomplete, in which only the mobile phone number of the purchaser's will be recorded for statistic collection purpose.

Fig. 12 depicts a preferred embodiment of the command and data flow **400** within the vending machine. It will be appreciated, however, that various alternate embodiments of the command and data flow **400** or any portion thereof are within the scope of the present invention.

As shown in Fig. 12, the process begins when the vending machine is power up **401**. When the AC power supply of the present invention is switched on, the MC executes its program stored in the EPROM. In a preferred embodiment, the program can initiate the wireless modem **402** and send an SMS message **403** to the central computer. The SMS message **403** can contain the vending machine ID and/or a set of codes to identify the request. The SMS message is capable of notifying the central computer that the transmitting vending machine is coming on-line.

Once the on-line message **403** is dispatched, the vending machine can wait for a return SMS that contains the vending machine's inventory setting **404** from the last power down. If no message is received from the central computer after a predetermined period of time has elapsed **410**, the program disables all the wireless purchase and on-line inventory functions **411** and sends a message to the display panel informing the user that the wireless purchase and on-line inventory system is disabled **412**. In such disabled mode, the vending machine can still be operated by coins **413**, but wireless purchase and on-line inventory functions are disabled. If the inventory setting **404** is received while the vending machine is in its operation mode (*i.e.*, before the predetermined period of time elapses), the program then proceeds to the next stage of wireless purchase and on-line inventory functions **407** as will be described below.

If the inventory setting **404** is received and verified, the program proceeds to enable the wireless purchase **407**. The inventory setting **404** received from the central computer may contain an instruction of disabling the wireless purchase function, but enabling the on-line inventory function **406**. This instruction allows the central computer to enable or disable the wireless purchase function at a chosen time. If the received setting **404** does not contain such instruction to disable the wireless purchase function, the program proceeds to enable the wireless purchase and on-line inventory functions **408** and sends an

appropriate message to the display panel **409**. On the other hand, if the received setting **404** contains the instruction to disable the wireless purchase function, the program proceeds to disable the interface with the coin mech signal simulation circuit. The program can also proceed to display **405** a message on the display panel of the vending machine that the wireless purchase function is disabled.

During the disable mode of operation, coin operation **451, 452, 454, 458** and on-line inventory functions **463, 464, 465, 466, 467, 468, 469, 470, 471, 472** are still fully supported. For the coin operation, the program checks **451** the state through the coin mech signal detection circuit. When sufficient coins are received by the coin mech, its output signals are activated to invoke the selection buttons on the display panel of the vending machine **452**. When dispensing occurs **454**, the transaction is completed. The transaction information is stored **458**. The program is capable of differentiating coin insertion **453** from mobile phone dial-in **455**. For the coin insertion, the program goes to enable merchandise **452**. For mobile phone dial-in, the program sends part of the phone number onto the display **456** and then enables merchandise selection **457**. During this phase, if dispensing is detected **459**, then the transaction is considered complete and stored **461**. Otherwise, a timeout loop will be executed **460**. If no dispensing signal is detected when the loop completes, the merchandise selection is deactivated **462**. The transaction is thus declared incomplete. Regardless whether the transaction is complete or not, the associated vending transaction information is stored in the memory bank. After the merchandise has been dispensed, the program proceeds to perform the on-line inventory function.

For the on-line inventory function, the program is capable of performing one or more the following tasks in any desired order. First, the program can check the sold out signals through the SOI circuit **464**. If a new sold out signal is detected in any of the storage compartments **466**, an SMS message is immediately sent **469** to the central computer to raise a warning for servicing. Regardless of the outcome, the program can further check whether it is time to perform a scheduled reporting **472**. If so, then all the vending transaction information in the memory is sent to the central computer **470**. Otherwise, the program returns to a state waiting for transaction **473** and checks whether the wireless purchase function is enabled.

Second, the program can check the inventory levels **463**. If the inventory level of one of the storage compartments is below a pre-set level **465**, then an SMS message is sent **469** to the central computer immediately to raise a warning for servicing. Regardless of the outcome, the program can further check whether it is time to perform a scheduled reporting **472**. If so, then all the vending transaction information in the memory is sent to

the central computer **470**. Otherwise, the program returns to a state waiting for transaction **473** and checks whether the wireless purchase function is enabled.

Third, the program can record the value of the quantity counter **468** and the state of the door switch and refill/service switch **471**. After that, the program can check whether it is time to perform a scheduled reporting **472**. If so, then all the vending transaction information in the memory is sent to the central computer **470**. Otherwise, the program returns to a state waiting for transaction **473** and checks whether the wireless purchase function is enabled.

Fourth, the program can check whether the power supply level is below a certain preset level **467**. This may happen when power supply is unstable or experiencing a transient, or when the vending machine is being power down. To avoid the problem of unstable power supply or transient, a predetermined period of time is incorporated in the detection. If the duration of the drop in supply level is short, then the program ignores the occurrence. Because the system contains a backup battery, a supply drop over a short period of time does not affect the operation of the present invention. However, if the drop in power level exceeds the predetermined period of time, a power down condition is confirmed. Once a power down condition is confirmed, all the vending transaction information and an identification message are immediately dispatched to the central computer **474**. After the messages are sent, the MC switches itself to a sleeping mode, which can be switched on when the normal power supply resumes **475**. When the vending machine is power up again, the program starts the power up sequence as described above.

Fig. 13 depicts a preferred embodiment of the configuration of the on-line inventory management approach **370** formed according to the principles of the present invention. In the preferred embodiment, the on-line inventory management approach **370** can consist of a plurality of vending machines **371** and a central control computer **374**. The vending machines **371** can be either a mechanical or an electronic type as described above and can be on-lined via the CCU wireless communication channel **382** and the commercial cellular mobile network **372**. Each vending machine **371** can be uniquely identified by a mobile phone number known only to the central computer **374**, while wireless purchase is invoked by dialing a short code unique to each vending machine **371**. The central computer **374** can be connected to the mobile network via a fixed line **384, 373, 383**, or a wireless modem. The central computer **374** can be also networked **378, 379, 380, 381** with the vending operator's server **376**, inventory database **375**, and on-line reporting procedures **377**. It will be appreciated that various alternate embodiments of the on-line inventory management approach **370** are within the scope of the present invention.

In an exemplary embodiment of the present invention, the central computer **374** can execute a program that performs one or more of the following tasks: being responsible for all the communications with all the vending machines, updating the server's inventory database when the vending transaction information is available, performing local house-keeping such as keeping a data and event log for all the information received, initializing, and maintaining the communication link with the vending machines and the operator's server and inventory database, supporting visualization of inventory data and individual vending machine status, and producing inventory data in a pre-defined report format for management purposes.

There are various types of communication between the vending machine **371** and the central computer **374**. One type of communication is the system on-line reporting, which is sent when the vending machine **371** is power up. The message informs the central computer **374** that the vending machine **371** is on-line. Upon receiving this message, the central computer **374** returns the last inventory data to the vending machine **371**, so that the vending machine **371** can begin its wireless purchase and on-line inventory functions. An alternative type of communication is the on-line scheduled reporting communication. This communication is pre-set to a time of a day, at which time the CCU packs all the vending transaction information into SMS message(s) and sends them back to the central computer **374**. Upon receiving the message(s), the central computer **374** updates the database, which in turn generates inventory reports. Another type of communication is the large content reporting, which is invoked at any time when the number of vending transaction information has exceeded a pre-defined threshold. This occurs when there is a sudden surge in the number of transactions.

A further type of communication is the alert reporting, which occurs when a new sold out signal or low inventory level is detected in any of the storage compartment. Upon detecting this condition, the CCU immediately sends an alert message back to the central computer **374**. The central computer **374** records the condition and flags it in the visualization. A still further type of communication is the power down reporting, which is similar to the other reporting of vending transaction information, except that there is an additional message attached to identify that the vending machine **371** will go off-line in a short while. One additional type of communication is the audit request initiated by the central computer **374**. This allows the central computer **374** to request inventory data and transaction information from the vending machine **371** at any time. Upon receiving this request, the vending machine **371** returns its vending transaction information to the central computer **374**. It will be appreciated that various alternate embodiments of the

communication between the vending machine **371** and the central computer **374** are within the scope of the present invention.

Fig. 14 depicts a preferred embodiment of the command and data flow **500** of the on-line inventory management formed according to the principles of the present invention. It will be appreciated, however, that various alternate embodiments of the command and data flow **500** or any portion thereof are within the scope of the present invention. The approach begins **501** with an initialization of the wireless modem or a fixed data line **504**. Once the communication is set up, the central computer polls to see whether an SMS message has been received **505**. If this condition is true, then central computer checks to see what type of communication it is. There can be various types of SMS messages to which the program will act accordingly as described as follows.

For an on-line message, the program proceeds to retrieve the setting of the originating vending machine from the database **512** and returns the setting to the originating vending machine immediately **513**. The event is then logged in a local log file **517**. The status of the originating vending machine is updated in the visualization **516**.

For a scheduled report message, the program proceeds to update inventory and transaction information in the database **511** and returns an acknowledgment to the originating vending machine **514**. The event is also logged in a local log file **517**.

For a large content report message, the program proceeds to update the inventory and transaction information in the database **511** and returns an acknowledgment to the originating vending machine **514**. The event is also logged in a local log file **517**.

For a power down message, the program proceeds to update the inventory and transaction information in the database **511** and returns an acknowledgment to the originating vending machine **514**. The event is then logged in a local log file **517**; the status of the message sending vending machine is updated in the visualization **516**.

For an alert message, the program proceeds to update the inventory and transaction information in the database **511**. The program further updates the status of the originating vending machine on the visualization **516** and/or enters the event into a warning report **515**.

If an audit request message **506** is issued, the program sends a request message to the target vending machine **507** and waits for its reply, with time out **509**. Upon receiving the vending transaction information **508** from the target vending machine, the program updates the database and returns an acknowledgment **510**. The event is then logged in a local log file **517**. If the request is time-out, the program flags this condition on the visualization and enters the event into a warning report **515**. If no audit request is issued, the program checks whether it is time for a scheduled database update **503**. If so,

the program can further update the database **502**. Otherwise, the program can return to wait for SMS message **505**.

It will be appreciated that the various features described herein may be used singly or in any combination thereof. Thus, the present invention is not limited to only the embodiments specifically described herein. While the foregoing description and drawings represent a preferred embodiment of the present invention, it will be understood that various additions, modifications, and substitutions may be made therein without departing from the spirit and scope of the present invention as defined in the accompanying claims. In particular, it will be clear to those skilled in the art that the present invention may be embodied in other specific forms, structures, and arrangements, and with other elements, and components, without departing from the spirit or essential characteristics thereof. One skilled in the art will appreciate that the invention may be used with many modifications of structure, arrangement, and components and otherwise, used in the practice of the invention, which are particularly adapted to specific environments and operative requirements without departing from the principles of the present invention. The presently disclosed embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and not limited to the foregoing description.